Quantitative Infrared Spectroscopy of Minor Constituents of Earth's Atmosphere

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Infrared spectroscopic techniques have become extremely powerful tools for use in achieving a number of observational objectives in understanding and monitoring the "health" of Earth's atmosphere. Prerequisite to designing appropriate instruments as well as to interpreting the observations that monitor the important molecular species, quantitative laboratory spectroscopic measurements must be done. The measurements provide (1) line and band intensity values that are needed to establish limits of detectability for as yet unobserved species and to quantify the abundance of those species that are observed; (2) line positions, half-widths, and pressure-induced shifts, all of which are needed for remote and in situ sensing techniques; and (3) data on these basic molecular parameters at temperatures and pressures appropriate to the real atmosphere.

Good progress has been made in calibrating the BOMEM Fourier Transform Spectrometer (FTS) intensity determinations with measurements obtained with the Kitt Peak interferometer on carbon dioxide (CO_2). The analysis for line intensities has begun for nitric acid (HNO_3) using infrared spectra previously obtained.

An experimental study was completed which demonstrates that magnetic rotation spectroscopy can detect free radical molecular species (in situ) in the part-per-trillion mixing ratio range. In connection with this work, measurements were done to establish Zeeman tuning rates in the infrared spectrum of nitrogen dioxide (NO_2).

Preliminary measurements have been made to measure line intensities and shapes of gaseous water in the 1-millimeter spectral region to help in understanding the apparent anomaly associated with absorption of solar radiation by clouds in Earth's atmosphere. The signal-to-noise ratio (S/N) on these spectra, recorded with the high-resolution BOMEM FTS and 25-meter base-path multiple-traversal absorption cell, were greatly enhanced by incorporating an infrared band-limiting filter wheel with S/N ratios greater than 1000 achieved in 30 minutes of integration.

This research was performed in collaboration with Linda Brown, Jet Propulsion Laboratory/California Institute of Technology; Mike Dulick, National Solar Observatory; Guy Guelachvili, University of Paris XI; Sumner Davis, University of California, Berkeley; Aaron Goldman, University of Denver; Ginette Tarrago, University of Paris XI; Nelly Lacome, University of Paris VI; Tom Blake, Battelle, Pacific Northwest Laboratory; and Chris Mahon, Space Physics Research Institute.

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Spreading and Growth of Contrails in a Sheared Environment

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The evolution of persistent contrails (condensation trails) has been modeled over time scales of 15–180 minutes using a large-body simulation model with detailed microphysics. Model results have been compared to satellite and in situ measurements of persistent contrails from the Subsonic Aircraft: Contrail and Cloud Effects Special Study. In particular, the evolution of the persistent contrail observed on May 12, 1996, was simulated. In simulations with large ambient supersaturations and moderate wind shear, crystals with lengths greater than 200 microns are generated within 35 minutes by depositional growth. In situ measurements in the May 12 contrail case showed that these large crystals did in fact form. The large crystals fall rapidly and the contrail's horizontal extent increases as a result of wind shear (see figure). Strong radiative heating (with